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# Rationale for Sequence of High School Science Courses: Argument for Change

James M. Moulton
*Bowdoin College*

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JAMES M. MOULTON
*Department of Biology*
*Bowdoin College*

In this time of rapidly evolving curricula, it is, I fear, redundant and presumptuous for a professor of biology to comment upon secondary school education. This is particularly so if he lacks experience in the problems of secondary school administration and teaching as does the present author. The problems of adequate preparation and appealing to student interests that one encounters at the college and university levels among relatively highly selected students are magnified many, many times at the high school level.

My only excuse for treading into the arena of secondary school science education is a continuing concern of two decades with university and college students recently exposed to the best of that education, and a close acquaintance with secondary school science teachers as friends and as students in NSF Summer Institutes in Introductory Biology (with particular reference to marine environments and materials) presented at Bowdoin College. In addition, our family of three youngsters was exposed to British secondary school curricula last year during a sabbatic leave, and the absolute impossibility of introducing reasonably bright American secondary school students simultaneously to a comparable age level *and* to a comparable level of science achievement in good British secondary schools was impressive and led me to think more about our own secondary school science education than I had hitherto done.

But my views are biased by experience limited for over sixteen years to teaching biology in a small college; extensive university experience would undoubtedly lead to other views. We have no graduate work at Bowdoin College, other than a master's degree granted by NSF programs in mathematics. All of our concern is then with undergraduates, and I am perhaps particularly attuned to their complaints and requirements because they receive my full attention in the classroom, as research associates and as human beings. Let me say initially that it is a very rare student who criticizes his secondary education. Complaint, when it occurs, rather seems to be centered on the current college experience.

There are two related problems to which I wish to speak: One is the

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flight from the sciences, declining enrollments in the sciences in an age and at a time when the need for citizens educated in science is outstanding. On the brink of a new day of technology, of health, of leisure time, of peace and stabilized population, these certainly to follow the presently mounting chaos, many students are turning from the natural sciences to the social sciences and humanities as more likely than the natural sciences to save the world.[1] Other attitudes may also be important. This problem is recognized internationally.[2, 3]

The second problem, and the one with which I am most concerned, is the problem of increasing enrollments at the college level in the life sciences. The reasons for growing interests in life sciences are probably multiple: in many places a particularly successful revision of high school curricula frequently based on BSCS materials, the draw of medical science as an attractive and challenging profession both in practice and in research, the sense of action in the life sciences and the pitch of the research effort. I doubt that we have yet seen the full impact of revised Selective Service practices on enrollments in the life sciences, nor upon the diminution in numbers of students applying for graduate work and the increase in numbers of students applying for the medical professions.

This discussion focuses upon the secondary school science curriculum leading to advanced education. Although we realize they are important problems, I will not be concerned here with general education nor with science for nonscientists, while recognizing them as important issues.

Upon receipt of Chairman Silber's letter in late January inviting preparation of this paper, I immediately corresponded with Jerry Lightner, John Mayor, Wayne Taylor, and Martin Schein as possible sources of information on significant statements on the secondary school science curriculum. These in turn referred me to others, so that statements and references have come to me from a wide variety of sources and I am most grateful to all of those who have tried to inform me upon so short a notice.

My own spring semester has been particularly busy, and I am sorry I was unable to take advantage of Wayne Taylor's kind offer to read this statement critically during its preparation. I have also discussed these matters at Brunswick, Maine, with friends and colleagues among whom should be mentioned especially Paul Hazelton, Professor of Education at Bowdoin College, and Claude Bonang, biology teacher and science coordinator for the Brunswick school system, as well as with colleagues in my own department. The matter of secondary school preparation in science was briefly discussed with the Education Committee of the American Society of Zoologists in April. I apologize for my emphasis upon biology before this committee, as well as for having included so much of a personal flavor and point of view for which I bear the responsibility. Faults reflect my ignorance.

The names of those who have been kind enough to write to me or to make inquiry for me in connection with this presentation are listed below. Although they are not all cited specifically in the text, the assistance of all of them is much appreciated: Walter Auffenberg, Chairman, Department of Natural Sciences, University of Florida; Jerry P. Lightner, Executive Secretary, The National Association of Biology Teachers, Inc.; Arthur H. Livermore, Deputy Director of Education, American Association for the Advancement of Science; Wendell F. McBurney, Coordinator for School Science, Indiana University; William V. Mayer, Director, Biological Sciences Curriculum Study; John R. Mayor, Director of Education, American Association for the Advancement of Science; Martin W. Schein, Commission on Undergraduate Education in the Biological Sciences; Victor Showalter, Research Associate, Educational Research Council of America Science Program; Robert Sund, Department of Science Education, Colorado State College; Wayne Taylor, Science and Mathematics Teaching Center, Michigan State University; Stanley E. Williamson, Department of Science Education, Oregon State University; and Robert E. Yager, Department of Science Education, The University of Iowa.

A relevant expression of the problem of declining enrollments in the physical sciences, as well as a caution against too great pessimism, was contained in an editorial in the New York *Times* on February 12, 1968, and reprinted in *Science* on March 8:

> Feelings of rejection and self-pity were apparently rife at the recent meetings of the American Physical Society in Chicago. Compaints were voiced of inadequate enrollment in physics courses, from the high school to graduate levels, as well as of declining financial support. One speaker referred to a "revulsion against science" throughout all American Society.
>
> Can it be that the Cassandras among the physicists have lost their historical perspective? Whatever the problems of American physics today, it is incomparably stronger in every respect than it was in the 1930's when only a relative handful of young people went into the field and when Government and private financial support in the volume now taken for granted was undreamed of.
>
> Physics does have genuine problems, of course. It is no longer the dominant glamour king of the sciences, as it was in the heyday of research in nuclear and solid state physics during World War II and the succeeding decade. Today much of the "action" has shifted to biology. As for shortages of students, the hard fact is that physics is a taxing subject and that competent and inspiring teachers are in very short supply, especially at the high school level.
>
> Yet the basic fascination and importance of physics and its still uncrossed frontiers remain very strong attractions indeed, and the national interest in maintaining a strong physics establishment is unquestioned.

Increasing enrollments in the biological sciences might be attributed to a number of causes other than the site of the "action": the impact of The Biological Sciences Curriculum Study in modifying the high school biology curriculum; opportunity for additional years of biology in high school which places an emphasis upon this science; the fact that biology is less generally quantitative than the physical sciences and thus perhaps somewhat easier to grasp. Whatever the reasons, at Bowdoin College seen as a microcosm of changes in the biological sciences, the number of majors in biology has grown from forty juniors and seniors in the fall of 1959 to sixty-eight juniors and seniors in the fall of 1967. Numbers such as these could hardly alarm the faculties of universities. In our small college of undergraduates, an increase such as this has a strong impact on programs directed toward graduate and professional education, yet administered in 1959 by a three-man faculty, now enlarged to five. At the same time we have tried to provide opportunities for independent work for every qualified student, this at a time of rising costs and somewhat declining support. The kind of growth in numbers we are experiencing in the 1960's also occurred in the 1950's. During these decades, the college has increased from approximately 775 to about 925 students, and enrollments in chemistry and physics have remained relatively stable.

The evolution of our major program in biology at Bowdoin College is perhaps not far from the main trend of the last decade and may thus serve as a model for discussion and criticism. In 1952 we had a three-man department of biology, with one teaching fellow. We hoped that students accepted to the college would enter with a firm background in mathematics and with biology, chemistry, and physics. We felt that prospective majors in biology should begin science in our four-course curriculum with mathematics and chemistry continued through the sophomore year, then beginning biology in the sophomore year, while taking courses in the humanities and social sciences. Physics is expected to have been passed by the end of the junior year.

The preceding still reflects our pattern of thought, the level of our anticipation, but now we have a five-man department, two teaching fellows, and a small number of technicians in a 900-man college. We have sixty-eight junior and senior majors for each of whom we have been asked to provide an opportunity for independent work. We have introduced independent study courses in addition to honors work, encouraging students to replace regular college courses with research courses constituting possibly up to one-eighth of the curriculum. We recommend as preparation for several of our courses prior preparation in chemistry through organic, and for some physical chemistry. Due to pressures of a four-course curriculum, physics is still likely to be a third-year elective; rarely is it a fourth-year elective or a summer school experience. Students are encouraged to bypass introductory courses in favor of advanced courses, depending on their secondary school preparation. If they have had more than one year of secondary school biology, they are expected to move directly to an upper-level course.

I have sensed that the second year of biology introduced into many secondary school curricula within the past decade, and much of modern high school biology generally, may have had an effect other than that intended. Glimpses are caught of many phenomena that should be studied in depth, and all too often the student arrives in college with the feeling that he has seen everything when in fact he has seen almost nothing of animal and plant science in the detail of understanding which historically has been the hallmark of science. The excitement of short, whirlwind experiments in carefully blueprinted laboratories is not necessarily good preparation for prolonged efforts and sometimes tedious, time-consuming techniques necessary to acquire data so important to advanced and professionally oriented scientists. Now with the possibility of a third year in biology being considered for some secondary school curricula, it is difficult to know whether physics and chemistry are keeping pace in the secondary school curriculum, and whether biology, chemistry, and physics should not increase in depth by increments more in step with each other.

That there is justification for interesting high school students in specialized areas of science is not denied. Oceanography [4] and conservation are being discussed as important (exciting) areas for high school curricula. While exciting and often controversial, should they replace more basic subjects in the college preparatory curriculum? However, that there is need for chemists prepared to work in the oceans is clear: " . . . the present enrollment of graduate students in the specialities is related to the numbers in each speciality of the total working force as follows:

| | *Working force* | *Students in training* |
|---|---|---|
| Biological oceanography | 48% | 55% |
| Chemical oceanography | 7 | 6 |
| Geological oceanography | 11 | 19 |
| Physical oceanography | 34 | 21 |

"The proportion of students now specializing in biology appears to be sufficient to maintain the present representation in the working force. The proportion of chemists in training is about the same as in the working force. Chemistry is, however, the most poorly represented specialty. We believe the proportion of students in this discipline should be greatly increased." [5]

Of 398 students accepted at Bowdoin College and matriculating in the classes of 1968 and 1969, the following secondary school science preparation was presented:

| | | |
|---|---|---|
| Physics, chemistry and biology | | 232 |
| 2 years biology | 27 | |
| 2 years chemistry | 22 | |
| 2 years physics | 6 | |
| | 55 (about ⅛) | |
| Biology and chemistry | | 72 |
| Biology and physics | | 16 |
| Physics and chemistry | | 46 |
| Biology alone | | 12 |
| Chemistry alone | | 12 |
| Physics alone | | 8 |

Despite the emphasis upon preparation in chemistry for the study of biology, the study of chemistry seems not frequently to precede nor accompany the study of biology in high school curricula, and the primarily European system of keeping the study of all three sciences apace for a number of years in university preparation [6] is not commonly heard of in this country. On the other hand, in parallel with the work of various commissions on science curricula in the United States, the Nuffield Foundation in Britain has supported preparation of new curricula in chemistry, biology, and physics, [7] that in biology being particularly successful, [8] and comparing favorably with BSCS efforts in this country.[9]

There has seemed a possibility that increasing enrollments in biological sciences in colleges and universities might stem from the relative success of BSCS materials in arousing student interest, relative perhaps to the corresponding success of special secondary school curricula thus far developed in chemistry and physics. The early introduction of students to biology in secondary school presents them with a subject which attracts their interest, and for which materials have been designed adequate for two or three years of imaginative teaching. There is no argument with the assumption that a high school curriculum should be interesting, nor with a natural interest in life science among students. There does seem to be some ground for debate over proportions if a Blue Version BSCS course in biology is taught without prior preparation in chemistry.

Despite excellent courses in general science, there can be little doubt that the study of high school biology would be enhanced by an intensive look at chemistry prior to beginning the study of the cell and of cellular metabolism, now so important an aspect of biological science. Both chemistry and physics could add immeasurably to the depth to which biology might delve. That there can be two kinds of biology, one for college course students and one for general course students, is of course a possibility, just as it is argued that there should be biology in colleges and universities for majors and for nonmajors, or science for scientists and for nonscientists. But whatever the curricular solution, that situation is to be deplored in which biology satisfies a requirement for a health course in the high school curriculum, and is required of every student at the entering level.

The proliferation of life science courses at the high school level is perhaps as well expressed in the following as anywhere:

> Roy High School, which opened in fall 1965, had an enrollment of 1,400. We had over 250 students in BSCS Biology I, over 100 in BSCS Biology II, and over 110 in BSCS S.M. (Special Materials). Also a course in BSCS laboratory methods and research is given to 16 laboratory assistants. . . . Thus, over one-third of the school's enrollment participate in biology courses. Biology III will be added to the curriculum in the 1967-68 school year. This course will be designed around an upgraded and independent study philosophy for average and above ability students.[10]

The dictum of a biologist, James D. Watson, that "We've reduced . . . life to simple chemistry,"[11] deserves the tools among scholars for its examination and rebuttal. And we need to be aware as we plan our secondary school curricula of the plea of the nonscientist: " . . . science teaching may need to broaden its own horizons so that implications of scientific thought be perceived as farther-ranging than is usually seen in science courses. Laboratory experiments are valid in their own right, but not enough attention is given to the experimenter as a factor in the experiment . . . Biology today cannot be reductionist. Man 'as nothing but . . . ' must be replaced by the larger vision of 'this . . . and more'."[12]

The degree of "far-range" which can be applied to a science is based on the preparation of the students in question. Thus for the study of the complexities of living matter, it would make more sense to follow a sequence as similar as possible to that of mathematics, chemistry, physics, biology, than to study the sciences in the order biology, chemistry, physics with parallel courses in mathematics as a high school curriculum in science. While it is not at all certain that all of biology can be reduced to the conceptual schemes of chemistry and physics, [13] both must provide background for an understanding of metabolism, of the cell, of the organ, and of the organism.

Neither The Biological Sciences Curriculum Study nor The Commission on Undergraduate Education in the Biological Sciences has recommended a specific science sequence for secondary schools. The admissions requirements of colleges and universities perhaps play the most significant role in science curriculum determination. In the course of preparing this paper, some of my own preconceived and uninformed notions have been destroyed. The BSCS texts are apparently not so widely used as I had assumed to be the case, and a second year of high school biology is not so frequent an offering as I had thought; it appears to be exceptional in United States high schools, [18] although not perhaps in those from which are derived the most challenging undergraduates. However, opinions vary, another estimate being that one biology course beyond general biology is offered in one out of four large secondary schools. [19]

With all the variation that exists in the secondary school curriculum in the United States, there tends to be a common pattern of biology, chemistry, and physics, taken in that sequence, but not necessarily by all students, even in college preparatory curricula. The historical reasons for this order are not far to seek: biology appeals to the natural interests of students; fairly sophisticated mathematics and vocabulary are required for physics and to some extent for chemistry; when a single year of science is required, biology would seem to be the most useful to the largest number of students in preparing them to understand what they see about them; biology has in the past been the least expensive science to present to large numbers; in an agricultural economy, biology was an important basic tool for all citizens; biology has a great deal to do with teaching the basic principles of good health and physical well-being to the broad spectrum of students. Given his own choice, each science teacher would probably wish his discipline to be the culminating one. Whatever the effect of the primary position of biology in shaping student attitudes toward science, this may be offset by an increasing frequency of second-year courses in chemistry and physics in high schools. The development of such offerings, along with improved curricula, may place an emphasis on physical sciences which may divert more students to these sciences in colleges and universities.

In addition to the admissions policies of colleges and universities, and the work of commissions in improving science education in high schools, a third and more recent influence for change is the development of new programs in the junior high. New work in mathematics and increasing emphasis upon physics and chemistry in new earth science programs are providing increasing background in the physical sciences prior to admission to high school and to the biology, chemistry, physics sequence. This trend may eventually reject the complaint that insufficient chemistry is mastered prior to beginning biology in the high school curriculum. There is in fact increasing concern for mapping science education through the whole educational program. A significant statement from this point of view describes the concern of the Commission on Science Education of AAAS with a program for grades 1 through 6, and from this program, projects science education of the near future on through high school. [14] To quote briefly from Dr. Livermore's article, "On such a base a modern biology course could stand firmly. This course should take a biochemical approach. It might be a modified form of the BSCS Blue Version, *Molecules to Man*—modified because the chemistry prerequisite would not now need to be included in the course itself. The student should have no difficulty understanding simple biochemical reactions, the transfer of energy in biochemical systems and the structures of biochemical molecules."

Dr. Livermore's article is suggestive of a third trend in science education in the United States, which has hardly had a significant trial as yet—namely, that of unified or integrated science programs which promise to come closer than other curricula perhaps to the European system of sequential offerings of the different sciences over several years, yet to improve upon that system by closer coordination and mutual enhancement of the different sciences. Discussion of a unified science program was led by John Richardson and James Skehan of this committee in October, 1967. [15] Increasing attention has been paid to such programs in recent years, [16, 20, 21,22] most frequently to combine courses in chemistry and physics.

An example of an integrated curriculum of science has been outlined for me by Stanley E. Williamson of Oregon State University; I take the liberty of quoting from his letter:

> One of the new approaches to senior high science is that being developed in the Portland Public Schools. In this program the major concepts in biology, chemistry, and physics are treated in an integrated manner rather than as separate entities. The program is in its second year and from all information that I have been able to gather from teachers and in working with those on the committee, it is highly satisfactory. For example, the topics discussed from the biological and physical science point of view in each of the three years are as follows:
>
> *Sophomore year*
> I. Preparation and quantification
> II. Properties of matter
> III. Energy and work
> IV. Ecology
> *Second year*
> I. Functions

II. Kinematics
III. Dynamics
IV. Heat and energy effects
V. Chemical and biochemical reactions

*Third year*

I. Structure and function in biological systems
II. Structure and function in physical systems
III. Structure and function in chemical systems

> . . . To really appreciate what is done one needs the complete outline. In general the two broad areas of science are quite well integrated, and I believe, make a very nice science program for the average and above high school student.

A more philosophical approach to unified science is that advocated by the Education Research Council of America and the Federation for Unified Science Education (FUSE):

> The term "unified science" was adopted as the general label for science courses in which subject matter from several disciplines is used. This is in contrast to traditional courses that typically emphasize one discipline for each school year . . . More and more science teachers are beginning to realize that curriculum reform is not something that needs to happen every ten or twenty years. Instead, the science curriculum must be subjected to continuous review and modification in the light of educational objectives and student needs and interests. The spirit of unified science education embodies the concept of continuing curricular evolution.[17]

An interesting strengthening of the junior high curriculum in preparation for high school science is in effect at The University of Iowa Laboratory School in Iowa City, and is summarized in a letter from Professor Robert E. Yager in the following table. The variation of science curricula is of interest, but perhaps the most unique feature of the program is the presentation of BSCS Blue Version biology at the 8th grade level.

SCIENCE CURRICULUM
AT THE UNIVERSITY
LABORATORY SCHOOL
Iowa City, Iowa

Required of all Students:
7th Matter (chemistry and geology)
8th Life (biology) Blue Version BSCS
9th Energy/Space (physics and astronomy)

One Year Required, Remainder Elective:

A

10th Chemistry
11th or 12th Advanced Biology-BSCS
Advanced Materials
11th or 12th Physics
11th or 12th Science Seminar*
11th or 12th Science and Culture

B

10th or 11th Earth Science
10th or 11th Physical Science
10th or 11th Biological Science-Ecology
11th or 12th Science and Culture

C

11th or 12th Applied Science

* Can be repeated

A. Academic courses for students who plan to continue with formal instruction in science.
B. General courses for precollege students who will not continue in science.
C. Course for students who do not plan to enter college.

The common thread to many of these programs seems to be one of strengthening of the science curriculum in pre-high school grades, in preparation for high school science. An important aspect of innovations in this area should be one of assessing their effect on accomplishment of high school students in the sciences and on the attitudes of students toward the sciences. It seems likely that in view of improving science preparation through junior high, the order of courses in the high school science curriculum will vary a good deal more in future than it does presently from school system to school system. But the trend toward unified science programs seems likely to have ultimately a more profound effect on science education than any other, for it cuts across traditional boundaries and should develop more unified concepts than traditional schemes. The mutual reliance upon each other of the natural sciences today may require a much greater unification of physical facilities as well as of syllabi in order to accomplish adequate preparation of students. The trend is reflected in new science centers and institutes of colleges and universities, in which men of several disciplines work together toward common ends.

Presently the science curriculum is evolving very rapidly, and it seems best to observe that evolution at present and not to recommend curricular fixation in any particular sequence or tradition. The past and present efforts of commissions both here and abroad continue to have their impact and must eventually result in overcoming any shortage or imbalance in science interest among high school students and the undergraduate and professional scientists they eventually become.

"It seems clear," writes A. H. Livermore, "that the ferment that is taking place in precollege science curricula is going to continue. College men and school men will continue to labor together to improve science teaching in the schools. To the teacher of science in college this means only one thing. His course, particularly if it is 'introductory,' cannot remain static but must be changed from year to year to reflect the improved quality of the science education of his students."[14]

I have no plan of action to present. Perhaps this committee in its discussions may develop one. My *feelings* are that:

(1) Where a traditional science curriculum exists, science preparation in the high schools should occur in the sequence of chemistry, biology, and physics, and that far preferable is a unified science program extending over three years.

(2) A second year of a single science at the high school level is of dubious value as an educational experience, and that undergraduates interested in science would be better advised to study mathematics, foreign languages, writing, and liberal arts generally. For the best students, opportunity should be provided for independent work, perhaps on a nonscheduled basis.

(3) Chemistry, biology, and physics should be insisted upon in college preparatory curricula, and receive equal emphasis through the school years.

FOOTNOTES

1. Abelson, P. H., 1968. Student response to external factors. Science, *160:* 17.
2. Lord Jackson of Burnley, 1967. Science, technology and society. The Advancement of Science, *24:* 1-10.
3. Cox, I. H., 1967. Why choose science? Factors affecting the choice of subjects at school and university. The Advancement of Science, *24:* 254-262.
4. Gordon, B. L., 1968. An ocean-science program for pre-college students. The American Biology Teacher, *30:* 106-108.
5. "Education and Recruitment of Oceanographers in the United States." A report by the Committee on Education and Recruitment of The American Society of Limnology and Oceanography, Inc., Limnology and Oceanography, suppl. to vol. *6:* v-xxiii. 1960.
6. Stone, R., 1965. Manchester Grammar School, in "British Secondary Education," edited by R. E. Gross. Oxford University Press. London. pp. 144-165.
7. Corbett, A., 1968. Reforming the school curriculum. New Society, *11:* 118-122.
8. Anderson, N. A., 1968. Nuffield Foundation biology—A review. The American Biology Teacher, *30:* 23-25.
9. Pearson, P. G. and W. B. Foster, 1967. Change in college biology—A case history. The American Biology Teacher, *29:* 366-372.
10. Jensen, L., 1968. A description of team teaching at Roy High School. The American Biology Teacher, *30:* 119-123.
11. Anonymous, 1968. DNA at 16 Divinity Avenue: An interview with James D. Watson. Scientific Research, *3,* No. 6: 25-30.
12. Carleton, R. H., 1968. The non-scientist speaks on science for a liberal education: Remarks by John Baker. The Science Teacher, *35,* No. 4: 12-14.
13. Tucker, J. L., 1967. Science education in a changing society. The American Biology Teacher, *29:* 390-394.
14. Livermore, A. H., 1965. Science in grades K through twelve: A prelude to biochemistry. Federation Proceedings, *24:* 884-887.
15. Richardson, J. S. and J. W. Skehan, 1967. Prospectus on a program of unified science for the attention of the Cooperative Committee. Unpublished.
16. Klopfer, L. E., 1956. Integrated science for the secondary school: Process, progress, and prospects. The Science Teacher, November, 1956: 27-31.
17. Showalter, V., 1967. FUSE and unified science education. Metropolitan District Science Review, *28,* No. 4, December, 1967.
18. Mayer, W. V. Personal communication.
19. Lightner, J. P., 1968. The outlook for high school biology teaching. The American Biology Teacher, *30:* 257-259.
20. Fowler, J. M., 1968. The interdisciplinary curriculum. Physics Today, *21,* No. 3: 58-61.
21. "Teaching Physics and Chemistry in a Combined Course." Report of the Beloit Conference, December 27-30, 1961, Beloit College, Beloit, Wisconsin.
22. "Joint Conference on Multidisciplinary Courses in Science." Cosponsored by the Commission on College Physics and the Advisory Council on College Chemistry, February 3-4, 1967, University of Chicago, Chicago, Illinois.
23. "Conference on Interdisciplinary Curricula in the Natural Sciences in the Liberal Arts College." October 20-21, 1967. Hope College, Holland, Michigan.

# DATES TO REMEMBER

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|---|---|---|
| December 26-31, 1968 | AAAS Convention | Dallas, Texas |
| February 5-8, 1969 | NARST Convention | Huntington-Sheraton Hotel, Pasadena, California |
| February 28-March 1, 1969 | Southeastern Michigan Junior Science and Humanities Symposium | Detroit, Michigan |
| March 7-8, 1969 | ISU Science Shortcourse | Ames |
| March 8, 1969 | Michigan Science Teachers Association Convention | Everett High School, Lansing, Michigan |